STATE OF CALIFORNIA

DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
Office of Materials Engineering
and Testing Services

# DEVELOP A DATA FEEDBACK SYSTEM FOR EVALUTING AC PAVEMENT PERFORMANCE

Final Report # CA/TL-94/21


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16. Abstract

This report presents a list of the data files that relate to the California Highway System and a summary of the information contained in each of these files. Each file system was developed for a specific purpose and most of them are nonrelational; e.g. incapable of interfacing easily if at all.

It is recommended that relational files be established to store construction data pertaining to structural section thicknesses, material quality, and construction procedures to optimize specification procedures which should consistently provide better performing pavements. Guidelines are provided for formats of four files. They are: New Construction, Rehabilitation, Maintenance, and Historical Surface Performance.

The job control language proposed as a model for the retrival system is Programming Language I (PLI) and Statistical Analysis System (SAS). A simple sequential method is proposed for the retrieval system.

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# CONVERSION FACTORS

## English to Metric System (SI) of Measurement

| Quality | English Unit | Multiply By | To Get Metric Equivalent |
|---|---|---|---|
| Length | inches (in) or ( " ) | 25.40 | millimetres (mm) |
| | | .02540 | metres (m) |
| | feet (ft) or ( ' ) | .3048 | metres (m) |
| | miles (mi) | 1.609 | kilometres (km) |
| Area | square inches (in $^2$) | $6.432 \times 10^{-4}$ | square metres (m $^2$) |
| | square feet (ft $^2$) | .09290 | square metres m $^2$) |
| | acres | .4047 | hectares (ha) |
| Volume | gallons (gal) | 3.785 | litre (l) |
| | cubic feet (ft $^3$) | .02832 | cubic metres (m $^3$) |
| | cubic yards (yd $^3$) | .7646 | cubic metres (m $^3$) |
| Volume/Time | cubic feet per | | |
| (Flow) | second (ft $^3$/s) | 28.317 | litres per second (l/s) |
| | gallons per minute (gal/min) | .06309 | litres per second (l/s) |
| Mass | pounds (lb) | .4536 | kilograms (kg) |
| Velocity | miles per hour (mph) | .4470 | metres per second (m/s) |
| | feet per second (fps) | .3048 | metres per second (m/s) |
| Acceleration | feet per second squared (ft/s $^2$) | .3048 | metres per second squared (m/s $^2$) |
| | acceleration due to force of gravity (G) | 9.807 | metres per second squared (m/s $^2$) |
| Density | (lb/ft $^3$) | 16.02 | kilograms per cubic metre (kg/m $^3$) |
| Force | pounds (lb) | 4.448 | newtons (N) |
| | kips (1000 lb) | 4448 | newtons (N) |
| Thermal Energy | British thermal unit (Btu) | 1055 | joules (J) |
| Mechanical Energy | foot-pounds (ft-lb) | 1.356 | joules (J) |
| | foot-kips (ft-k) | 1356 | joules (J) |
| Bending Moment or Torque | inch-pounds (in-lb) | .1130 | newton metres (Nm) |
| | foot-pounds (ft-lb) | 1.356 | newton-metres (Nm) |
| Pressure | pounds per square inch (psi) | 6895 | pascals (Pa) |
| | pounds per square foot (psf) | 47.88 | pascals (Pa) |
| Plane Angle | degrees ( ° ) | 0.0175 | radians (rad) |
| Temperature | degrees fahrenheit ( ° ) | $\frac{°F - 32}{1.8} = °C$ | degrees celsius (° C) |
| Concentration | parts per million (ppm) | 1 | milligrams per kilogram (mg/kg) |

## NOTICE

The contents of this report reflect the views of the Office of Pavement, which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Neither the State of California nor the United States Government endorse products or manufacturers. Trade or manufacturers appear herein only because they are considered essential to the object of this document.

## ACKNOWLEDGEMENTS

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## INTRODUCTION

Over the years, a great deal of information has been generated regarding the design, construction and maintenance of the California Highway System. As the need for specific records became apparent, file systems have been developed to retain pertinent information such as soils and materials test data, traffic criteria, structural section thicknesses, condition survey data and records of maintenance and rehabilitation. Although some of the more recent data is easily accessible by computer, there is a great deal more information that is not. Materials tests and construction records, for example, are generally available only in hard copy files. Even some of the electronic records are stored in independent files that are non-related which makes it difficult to retrieve, compare and analyze the stored information.

Because of the constantly rising cost of highway construction, maintenance and rehabilitation, along with the greater demand on available funds, it is increasingly important that the most cost effective highway design, construction and maintenance be utilized. A major step toward this end would be to develop a program that allows the retrieval of all data stored in various files. If these data were made available on coordinated or relational files, it would be possible to evaluate or compare the performance of various features and/or conditions on different pavement structural sections. This would make it easier to predict pavement life for a given material as well as help to select the optimum materials and specifications for pavement design, construction and maintenance.

The objective of this study was to develop a data storage and retrieval system which will provide convenient access to all available design, materials, construction, maintenance, rehabilitation and performance data. To achieve this objective, the study was divided into three basic phases: 1) to identify and evaluate the data fields that are currently being used by Caltrans; 2) to propose any necessary modification of existing files to make them relational to one another; and 3) to develop a system for the retrieval of selected data from more than one file so that various factors can be compared.

## CONCLUSIONS

The Pavement Management System (PMS) files contain information on the distress status of pavements at approximately two-year intervals since 1978. Excluding the Skid Resistance Inventory file, the other existing computer files provide very little if any pavement performance information.

Interfacing selective files such as PMS and The State Highway Log with detailed construction files can be utilized to establish a performance evaluation for specific materials and/or specifications used in highway construction.

Information pertaining to the pavement structural section and properties of the construction materials of constructed roadways exist on as-built drawings, microfiche and hard copy. A substantial effort will be required to recover and transfer these data into computer files, especially on a statewide basis.

## RECOMMENDATIONS

It is recommended that relational files be established to store construction data pertaining to flexible pavement structural section thicknesses, material quality and construction procedures for the purpose of evaluating the performance of these materials and construction practices so that specifications and procedures can be optimized. These files should be established on all future projects; however, consideration should be given to recovering data from hard copy in existing files of selected completed projects. It is further recommended that files be established to collect maintenance and rehabilitation data for the purpose of optimizing strategy in these areas. General guidelines are as follows:

1. Make a concerted effort to standardize terms, abbreviations and format to accommodate existing usage in as many of the existing files as possible when preparing the format for the new file.

2. Use the file format and examples presented in the appendix to develop the final models.

3. Assign staff and responsibility for developing, maintaining and utilizing the file to one unit such as the Division of Maintenance, Office of Roadway Maintenance with staff support provided by Construction Engineering and Management, Informational Services and New Technology, Materials & Research.

4. Consider a similar program for rigid pavements.

## IMPLEMENTATION

An ad hoc committee comprised of personnel from the Offices of Roadway Maintenance, Construction Engineering Management, Project Planning and Design, and Pavement should review these recommendations and establish the specific guidelines for the desiginated files. It is possible that PC systems will be preferred to mainframe programs. If not the Division of Informational Services must be involved in the planning.

## DISCUSSION

The first phase of this project was to identify and evaluate the flexible pavement data files that are currently being used by Caltrans. Because of the complexity of the highway program, important information is scattered among numerous files which are maintained by various divisions. In some cases, data is duplicated in different files since each file was developed and maintained independent of all other files. This independent and frequently nonrelational approach makes it extremely difficult to cross reference, mesh or correlate the data stored in various files. A goal should be to make specific files relational so that the parameters in these files could be merged or interfaced. This would allow the performance of a particular pavement design to be evaluated much easier than it was in a 1978 study titled "Statewide Flexible Pavement Performance and Deflection Study" (1). In that study the absence of structural-section records required pavement coring at each test section just to determine the pavement thickness. With complete, accurate records, coring and measuring will be unnecessary. Also, improved technology in the future may make it possible to periodically monitor pavement conditions and deflections under a continuing audit program. When this occurs, the value of accessible construction data will become even greater as data from the condition survey files are combined to assist the monitoring of pavement performance and progressive deterioration on a statewide basis.

One application of historical data was utilized when the Office of Pavement, working with the Office of Highway Maintenance, developed software to select data from the Pavement Management System data file. Pavement-condition data before the placement of chip seals was compared to the service achieved with the chip seal strategy to evaluate the performance. It is expected that this information will reveal circumstances which contribute to the success of this strategy and result in improving criteria regarding when to place a chip seal.

The development of one beneficial file can be attributed to the fact finding process associated with this research. Sometimes the evaluator encounters a chip-sealed surface during the pavement rehabilitation evaluation. A program was implemented into the rehabilitation design procedure to provide the distress conditions existing prior to the placement of the chip seal. A sizable savings has been realized using this method. This appreciable savings is considered small when compared to the potential savings for a program using all of the data files over several years.

Future applications of performance data might include the evaluation of the effectiveness of AC overlays in reducing ride score, in retarding reflection cracking or in reducing pavement deflections. In addition to developing new research projects or investigations, data can be accumulated to supplement and refine prior research findings such as "Profile Index Requirements for Asphalt Concrete Pavements "(2). At a time when rubber and other polymers are being used in asphalt cement to provide improved properties, a data feedback program will allow researchers to study many projects over a broader range of conditions

A brief summary of the content and purpose of the various pavement-related files that exist within Caltrans is presented below. It should be noted that this information was gathered through interviews with personnel primarily responsible for the files, and therefore is only as accurate as the interview process.

1. PAVEMENT MANAGEMENT SYSTEM FILE

The Pavement Management System (PMS) file contains data on the condition of rigid and flexible pavements. This information is used in the decision making process when developing and scheduling pavement maintenance or rehabilitation projects.

The PMS file was developed by the Office of Highway Maintenance and is maintained by the Office of Roadway Maintenance. The first statewide survey under this program was completed in 1978 and is updated at periodic intervals.

The data in the PMS file is coded onto a magnetic storage device and it's original format has not required modification since the program was initiated. Because of characteristic differences in flexible and rigid pavement problems and remedies, the two types of pavement are handled separately in the PMS files. Only the data pertaining to flexible pavements are referenced in this report since the objective is to evaluate a system for AC pavement performance.

Information obtained from each survey is summarized in a printout "Flexible Pavement Condition Inventory Report". Pavement conditions are described by distress type and severity. "Trigger values" of these data are established to identify roadway locations in need of repair. For example, a flexible pavement exhibiting over

30 percent Type B alligator cracking would trigger a repair strategy calling for a structural analysis based on measured deflections.

Information stored in the PMS file includes:

- The average annual inches of precipitation
- Average Daily Traffic (ADT)
- Truck % of ADT
- Ride speed/Ride score
- Skid Numbers
- Present Serviceability Index
- Distress conditions
  - Cracking
  - Raveling
  - Rutting
  - Patched areas
- Condition of shoulder

## 2. CALIFORNIA STATE HIGHWAY LOG

The California State Highway Log contains a great deal of information about general characteristics of California highways. It is an inventory of all highway routes adopted or established by legislation.

Although this file does not include information pertaining to the structural section or the performance of various materials, some of the roadbed information is pertinent to the development of surface performance files. Information stored in the California State Highway Log for specific locations includes the following:

- Location
  - Postmile and county odometer
- Federal Aid Information
  - City code (Inside or Outside)
  - Rural, or Urbanized
  - Toll and Forest Highway
  - National Land
  - Scenic Freeway
  - Highway Group (Divided or Undivided)
  - Access Control

Roadbed Information
- Surface Type (Bridge, PCC, AC, etc.)
- Number of Lanes
- Special Features
- Traveled Way Width
- Outside Shoulder Width
- Inside Shoulder Width
- Median Information
- Curb and Landscaping Information
- Barrier Information
- ADT Information

## 3. HIGHWAY PERFORMANCE MONITORING SYSTEM

The Highway Performance Monitoring System (HPMS) file was developed by The Division of Transportation Planning in 1981 at the request of FHWA. It is basically a statistical summary of highway conditions and is used primarily as a continuing information system to support various reports to Congress; to support day-to-day programs and policy evaluations; to satisfy routine planning data needs; and to respond to continuing inquiries and requests from the Administration, Congress, and the public. Although it contains information about the structural section thickness of pavements, the data is believed to be too general to be beneficial for classification purposes.

Information in the HPMS file includes the following:

- Section/Group Length
- Rural or Urban Area
- Type Section/Grouped ID
- Functional Class
- Federal-Aid System
- Federal-Aid System Status
- Route Signing
- Government Level of Control
- Federal, State, Local Domain
- Special Systems
- Type of Facility
- Toll
- Shoulder Type
- Median Width
- Operating Speed
- Right-of-way Width
- Widening Feasibility
- Horizon Align Adequacy
- Vertical Align Adequacy
- Passing Sight Distance ≥ 1500 ft., %
- Speed Limit
- Average Highway Speed
- % Trucks
- Prevailing Signalization

Volume Group Identifier
Number of Through Lanes
Expansion Factor
Surface/Pavement Type
Pavement Section Classification
Structural Number or Slab Thickness
Pavement Condition
Access Control
Lane Width
Approach Width
Num of Structures
Capacity
Volume/Capacity Ratio
Accident Data
Curves by Classification
Typical % Green Time
Parking: Peak/Off-Peak
Future Average Annual Daily Traffic
Drainage Adequacy
Type of Development
Urban Location
Num Grade-Seprtn Intrchns
Num of Major Access Ptns
Num At - Grade Intrchns
Num At Grade RR Crossings
Type of Improvement
Improvement Cost Data

4. MAINTENANCE MANAGEMENT SYSTEM FILE

The Maintenance Management System (MMS) file is a budget oriented file maintained by the Office of Resource Management. Although this file includes data for both major and minor maintenance projects, it is the only file designed to accommodate minor projects which are defined as having a total cost less than $25,000.

The MMS file has been stored on magnetic storage devices since 1970; however, because of major format revisions that have been made over the years, it would be very difficult and expensive to recall information on projects prior to 1982.

The data in the MMS file is divided into 15 categories of which only "Flexible Pavement" is of interest for this study. This category included the following subdivisions which are quantified by labor hours and dollars, equipment costs and materials quantities and cost:

1. = Crack/Joint Repair
2. = Poor Ride Quality
3. = Structural Pavement Failure
4. = Pot Holes/Localized Depressions
5 = Preventative Maintenance
6. = Miscellaneous

The major MMS file is maintained in hard copy form by the Office of Highway Maintenance (OHM). By definition, a major maintenance project can cost between $25,000 and $125,000. Unlike the minor maintenance file, which is a budget oriented file, the major maintenance file is a project oriented file.

Data in the major MMS file provides general descriptions of the maintenance strategy such as "chip seal" but does not include details such as chip size or application rate. However, even without specific detail, this has provided valuable information. The Office of Pavement has coded information from this hard copy file onto a personal computer floppy disk and then used it to evaluate the effectiveness of maintaining pavements with chip seal applications.

The following information is included in the file:

- District
- County
- Route
- Begin PM
- End PM
- Expenditure Authorization
- Month and Year Built
- Type of Improvement

5. REHABILITATION FILE

The Office of Roadway Maintenance also keeps a file of rehabilitation projects. Rehabilitation projects differ from maintenance in that they are paid for from capitol outlay funds, rather than maintenance funds, and they are not restricted by the same cost limitations. Although rehabilitation projects can be very small, they generally involve more that $100,000, and frequently involve more than one million dollars.

Information on rehabilitation projects has been recorded on the magnetic storage device of a mainframe computer since 1972. However, prior to 1982, only a portion of the projects were included in this file. Since the primary purpose of this file is to record project costs, it may not contain adequate data for detailed analysis of the performance of structural sections of AC pavement. It can be used, however, to determine if rehabilitation work has been required since the initial construction.

The data in this file has been coded onto a SAS data set, and is readily accessible for anyone to use. The complete list of fields on the data set is listed below.

| | | |
|---|---|---|
| DIS | = | District |
| CO | = | County |
| RTE | = | Route |
| B | = | Back Post Mile Prefix |
| BKPM | = | Back Post Mile |
| F | = | Ahead Post Mile Prefix |
| AHPM | = | Ahead Post Mile |
| AMO | = | Award Month |
| AYR | = | Award Year |
| AFY | = | Award Fiscal Year |
| ALLOT | = | Project Allotment |
| BID | = | Low Bid |
| EA | = | Expenditure Authorization |
| EST | = | Engineer's Estimate |
| PI | = | Priority Index |
| PRG | = | Program Code (e.g., HA22) |
| PT | = | Project Type (e.g., AC overlay on AC pavement) |

## 6. PERSON YEAR AND PROJECT SCHEDULING AND COST ANALYSIS FILE

The Person Year and Project Scheduling and Cost Analysis (PYPSCAN) file is maintained by the Division of Budget Development and Administration.

"PYPSCAN" is compromised of computer tables and programs, and is used to calculate person-year requirements based on project information contained in the Project Management Control System (PMCS) file. It computes project schedules and estimates project related PY's based on Work Norms, Project Type, and Milestone Type necessary to complete a project. These PY's are then summarized by function (i.e. Project Development, Right of Way, Construction, etc.) and fiscal year. The data has been coded onto a magnetic storage device, and contains information on projects classified as major rehabilitation (HA), new construction(HB), reconstruction (HE), or highway maintenance (HM) since the 1972/73 fiscal year.

Since this file is primarily concerned with the budgeting process, it's primary contribution to the proposed data retrieval system would be to identify expenditure authorizations. At the present time, it does not distinguish between flexible and rigid pavement projects, but other files such as the PMS file can provide this distinction. The PYPSCAN file is also strongly interrelated to the PMCS file which is another budget-oriented file that is primarily concerned with the five-year State Transportation Improvement Program (STIP.)

It is believed that the PYPSCAN file provides more complete information on all types of paving activities than the maintenance files because of its earlier origin date and because it includes all of the projects classified by HA, HB, HE, and HM program codes. This data would be useful in locating projects for the purpose of retrieving specific information that is stored in "as-built" drawings, micro-films and hard copy files.

To accommodate the proposed storage and retrieval system, one of the authors has developed a program to reformat and transfer all paving activity records from the PYPSCAN file into a separate file. The program format is shown on the following page.

RECORD FORMAT FOR PYPSCAN DATA SET

| FIELD DESCRIPTION | START COLUMN | FORMAT |
|---|---|---|
| User ID | 01 | 'TM' |
| Record ID | 03 | '006' |
| Record Modification | 06 | '1' |
| State | 07 | 'CA' |
| District | 09 | NN |
| County | 11 | AAA |
| Route | 14 | NNN |
| Route Suffix | 17 | A |
| Direction | 18 | 'B' |
| Filler | 19 | XXX |
| Lane ID | 22 | 'A' |
| Filler | 23 | XX |
| Date Completed (Yr) | 25 | NN |
| Roadway Section ID | | |
| Post Mile Prefix | 27 | A |
| Post Mile | 28 | NNN.NNN |
| Filler | 35 | X |
| Post Mile Prefix | 36 | A |
| Post Mile | 37 | NNN.NNN |
| Filler | 44 | X |
| Roadway Section Location | | |
| Filler | 45 | X |
| Sequence of Record | 46 | NNNNNNN |
| Filler | 53 | 14X |
| Project Type | 67 | AA |
| Filler | 69 | X |
| Contract Number | 70 | NNNNNN |
| Descriptive Remark | 76 | 42A |

Available Catalogued Data Set

TMMLL.TM0061.PYPSCAN

**********

DCB=(RECFM=FB,LRECL=120,BLKSIZE=12000)

## 7. PAVEMENT LIFE HISTORY FILE (DISTRICT 11)

In July 1986, District 11 published an article (3) in their District Newsletter describing a "Pavement Life History" file that had recently been developed by members of their Pavement Management staff. It required a great deal of effort to collect the data from various files and to code it onto magnetic storage devices, but District 11 now has the capability of recalling technical data and route history with a basic computer command.

The initial file, which contains information such as location, when and by whom the road was built, the original structural section, and the dates and extent of rehabilitation and major maintenance, occupied about three Mass Storage System (MSS) cylinders with a Fixed Block (FB) record format. The file was later changed to a standard format that occupies four MSS cylinders with a Variable Block (VB) record format. The record format for the file is shown below:

RECORD FORMAT FOR PAVEMENT LIFE HISTORY FILE FROM DISTRICT 11

| FIELD DESCRIPTION | START COLUMN | FORMAT |
|---|---|---|
| User ID | 01 | 'TM' |
| Record ID | 03 | '006 |
| Record Modification | 06 | '0' |
| State | 07 | 'CA' |
| District | 09 | '11' |
| County | 11 | AAA |
| Route | 14 | NNN |
| Filler | 17 | X |
| Direction | 18 | A |
| Filler | 19 | 3X |
| Lane ID | 22 | N |
| Date (Mo/Yr) | 23 | NNNN |
| Roadway Section ID | | |
| Filler | 27 | X |
| Post Mile | 28 | NNN.NNN |
| Filler | 35 | 2X |
| Post Mile | 37 | NNN.NNN |
| Filler | 44 | X |
| Filler | 45 | X |
| Sequence of Record | 46 | NNNNNNN |

| | | |
|---|---|---|
| Filler | 53 | 10X |
| Section | 63 | N |
| Date Sequence | 64 | A |
| Class | 65 | N |
| Region | 66 | N |
| Type of Remark | 67 | AAAA |
| Filler | 71 | X |
| Remark | 72 | ≤ 75A |

## 8. NON-ELECTRIC MEDIA FILES

A variety of hard copy files can be found in various Caltrans divisions and offices. Records of completed contracts are stored in the State Records Center in West Sacramento and most pertinent data are kept in District files. Some records are maintained at the Division of New Technology, Materials and Research.

Of particular interest to one aspect of this data retrieval system is the pavement deflection data that is accumulated and stored in hard copy file by the Pavement Rehabilitation unit of the Office of Pavement. The file contains historical correspondence, field deflection test data, relevant comments on existing pavement conditions at the time the deflections were measured, reduced test data and alternative recommendations for the rehabilitation of specific sections of highway. Only the reduced deflection test data and pavement condition criteria would be practical to code onto a magnetic storage device.

Pavement structural section information such as type, quality, and thickness is necessary for the evaluation of pavement performance. This information can be found in the project special provisions but should be confirmed by the as-built plans. Unfortunately, even the as-built drawings are not always correct because an update is sometimes inadvertently omitted. Recovering structural section data requires reviewing hard copy or microfiche files which must be identified by contract number. Structural section data is included in all rehabilitation reports.

Quality requirements and test data indicating the properties or quality of basement soils and construction materials used in a project are recorded in either the materials report or the project files. When a contract is completed, the project file is sent to the Records Center for storage. Materials data is extremely important

to evaluating pavement performance, but it can be recovered only by reviewing the contract files.

Other files are no doubt available but those listed above contain the bulk of the information vital to an effective system.

## DEVELOPMENT OF A FILE SYSTEM

A cursory review of the existing files reveals that most of the pavement design and performance data needed for the proposed retrieval system is already available. However, it is not all available in a single file, nor is it always readily accessible. Furthermore, because of the vast variety and quantity of information stored in the various files it would not be practical, or possible, to combine it all into a single file.

The advantages of standardizing the format for all types of data sets will outweigh the advantages of using a more efficient format of each specific type of data set. In fact, overall, the result could be a significant decrease in storage because some duplication of data in each file can be avoided with the use of relational files. Therefore, to establish a data feedback system the first task should be to make all of the appropriate data storage files relational. This will make it possible to quickly and accurately retrieve and analyze selected combinations of data even though they are not stored in the same file. To achieve this, it is necessary to standardize the description of the formats and fields of the various records for the more important files, and then to centrally locate that documentation. Centrally located files with columnar types of records will be easier to maintain and to update than an all-encompassing data dictionary for the names of the variables used in the files. Additional support is provided for the columnar type records because people like to assign their own unique names to certain parameters which would require frequent updates to the dictionary and possible confusion.

Some departmental divisions maintain their data in Data Base Management System (DBMS) type of files such as Rapid Access Management Information System (RAMIS) or Statistical Analysis System (SAS) files. Others maintain their data on files having columnar types of records. The advantage of files with columnar types of records become apparent when browsing or editing a file on certain types of on-line systems, especially if the file is a relatively large file such as the PMS file.

The common item in most of the files is the location identification system (District-County-Route-Post Mile) and/or contract numbers. In some cases, it will be necessary to reformat existing electronic media files to make the data relational. This will require a small effort compared to the effort necessary to code and transfer existing hard copy files to electronic media.

The task of recovering data for existing roadways and transferring it from hard copy files is too labor intensive to justify. However, a great deal of information can still be accumulated by initiating a program to collect data from future projects.

Since the life-span of most flexible pavement is less than twenty years, relevant information would become available within a few years if a procedure is established to record the data from current and future construction, maintenance and rehabilitation projects as they are undertaken. The Resident Engineer or the Maintenance Superintendent of every project involving roadway construction or improvement should complete a standard report form providing specific details on the materials, climate and procedures relating to each project. Emphasis should be placed on verifying the climate data from another source because of the reluctance of field personnel to document placing a material in non-specification conditions. Frequently, it may be necessary to verify or determine the thickness and type of materials in each element of the existing structural section at the time repair or rehabilitation work is conducted. In may cases this will require coring the existing pavement. The completed form would be forwarded to the office responsible for maintaining the files.

Most of the files that are currently on magnetic storage devices are relational in their present form. The primary need at this time is to create new electronic media files for storing data that is presently available only in hard copy or microfiche files.

In preparing the proposal for a file system it became apparent that different opinions exist regarding the preferable way to identify specific sites for data retrieval. Changes have been considered that vary from minor ones requiring a postmile prefix character for all locations to minimize errors resulting from someone inadvertently dropping a prefix, to revising the existing system completely. It is beyond the scope of this project to determine whether to accept the existing postmile system used by Caltrans, to make some modifications to it, or to change the system completely. Since the engineer formatting this data system believes that changes are necessary for an efficient data retrieval system, some options are included in the proposed format. It is possible, however, that nomenclature associated with the Geographical

Information System, GIS, or Global Positioning System, GPS, that Caltrans adopts will resolve this issue.

Once a decision is made regarding the changes in our current procedure, if any, it should be easy to reject any of the unwanted proposal and establish the appropriate format. Prototypes of formats for the file data for new construction, rehabilitation, maintenance, surface performance, and environmental conditions are listed in Appendix I.

## DEVELOPMENT OF A RETRIEVAL SYSTEM

The final phase of this study was to develop a data retrieval system capable of recovering selected information from appropriate files to prepare a performance report. Producing a report from discrete files requires two phases: 1) selection and 2) reporting. When using non discrete files, a third phase (editing) is required. The editing phase is used to convert the non discrete record items into discrete record items.

In the mid to late 1980's, the following files contained flexible pavement data in a retrievable format. Each file is categorized by year. Each "TM0040.FLEX.PMS100" file occupies about nine MSS cylinders. The "TM0060.DIST11" file occupies about four MSS cylinders. The "TM0061.PYPSCAN" file occupies about one MSS cylinder. An example is provided in Appendix II to illustrate access to these files and to propose a model for retrieving data.

The Job Control Language (JCL) for the retrieval system proposed as a model in this report uses two programming languages; Programming Language I (PLI) and Statistical Analysis System (SAS). The PLI language was chosen because of its efficiency in searching the files and selecting pertinent records. The SAS language was chosen for editing and reporting because it is more powerful, i.e. provides many options easily.

The retrieval system can utilize a direct access method or a sequential method. The proposed retrieval system uses a simple sequential method of searching for a record for reasons discussed below. One of the most important advantages of such a method is that the files do not have to be sorted if any changes are made to any one of them. The disadvantage is that it can be a very slow method when searching relatively large files. Two techniques can be used to speed up the process. The first

is to reduce the size of some of the larger files. For example, the type TM0040.FLEX.PMS100 files each occupy about 9 cylinders, even though they have been categorized by year-of-survey. If this type file were to be further categorized by county, for example, most files would be reduced to approximately 1/50 the current size. The second technique is to utilize a "direct access" method of searching. The disadvantage of using a direct method of searching for records is that an entire file must be sorted whenever any of its records are updated or whenever the selected fields are changed. Sorting very large files can be expensive if done frequently. After considering the advantages and disadvantages of the two methods and the access frequency, it was decided that the sequential method of searching is preferable to the direct method for the files involved.

A proposed retrieval system model followed by an example is presented in Appendix II. The proposed model which selects records by District, County, Route, Begin PM, and End PM is very basic. However, the PLI program can be modified easily to select records by Record ID Field Column (s), and Field Value (s).

The example illustrates executing the PLI program to select the records and the SAS program to edit the selected records. The following commands are utilized:

| | |
|---|---|
| STEP111C | Initiates the PLI search and select program |
| STEP2222 | Initiates the SAS edit program |
| STEP3333 | Initiates a SAS report program |

All of the data sets are password protected.

## REFERENCES


(1) Skog, J., Matthews, J., Mann, G., and Roberts, D. "Statewide Flexible Pavement Performance and Deflection Study," California Department of Transportation, Transportation Laboratory, Report No. FHWA-CA-TL-78-36, December 1978

(2) Alexander, M., "Profile Index Requirements for Asphalt Concrete Pavements," California Department of Transportation, Transportation Laboratory, Report No. CA/TL-85/17, December, 1985.

(3) Main, R., "So You Think You Know The Road," District 11 News Bulletin, Department of Transportation, San Diego, California, July 1986.

APPENDIX I

FIELD DESCRIPTIONS

User ID

A set of characters that will uniquely identify the user (e.g., TM = New Technology Materials and Research)

Record ID

A set of characters that will uniquely identify the type of records (e.g., 001)

Record Modification

A character that will uniquely identify any minor changes in the coding or the format for a particular type of record. The modifications should be coded in sequence, as follows:

0, 1, 2, ..., 8, 9, A, B, ..., X, Y, Z.

Project Identification

State, District, County, Route

Route Suffix

| | | |
|---|---|---|
| S | = | Supplemental Route |
| U | = | Unrelinquished Route |
| Z | = | Budgeted Or Unconstructed Route |

Direction

| | | |
|---|---|---|
| L | = | Left of center line when facing in the direction of increasing post mile values |
| R | = | Right of center line when facing in the direction of increasing post mile values. (Note: The TASAS file, which is perhaps the most descriptive file using the present post mile system, uses the code or letter "Z" to refer to both sides of the center line when facing in the direction increasing post mile values. This type of code should be avoided except when printing reports. |

Number of Lanes

The first column specifies the number of lanes in the left (L) direction, and the second columns specifies the number of lanes in the right (R) direction. Always specify the number of lanes in each direction.

Lane ID

The first column is used for permanent identification. The original identification system begins with the letter, I, for the initial inside lane.

Second column is used for temporary identification, where the number 1 always identifies the inside lane or lane next to the median.

For example, four lanes originally constructed in one direction would be numbered as follows: I1, J2, K3, and L4. If two (2) lanes were added, one within the median, and the other outside, the six lanes would be numbered as follows: H1, I2, J3, K4, L5, and M6. The coding aids any subsequent evaluations by identifying where the widening occurred.

Use the following codes for all lanes, middle lane, and shoulders:

| | | |
|---|---|---|
| pR | = | All lanes in the right direction, where "p" identifies the inside permanent Lane ID. e.g. in the above example, HR indicate all lanes in the right roadbed. |
| pL | = | All lanes in the left direction, where "p" identifies the inside permanent Lane ID. |
| #M | = | Middle Turning lane (Both right and left roadbed) |
| #I | = | Inside Shoulder |
| #O | = | Outside Shoulder |

Date

The date of pavement construction prefixed by C.
The date of pavement rehabilitation prefixed by R.
The date of pavement maintenance prefixed by M.
The date of pavement evaluated prefixed by E
The date of environmental input prefixed by I

Post Mile Prefixes - Proposed System

| | | |
|---|---|---|
| A | = | Original alignment (Note: The original alignment is presently identified with a blank or no prefix.) |
| R | = | Realignment of A mileage. |
| M | = | Realignment of R mileage. |
| N | = | Realignment of M mileage. |
| D | = | Duplicate post mile meandering county line. |
| H | = | Realignment of D mileage. |
| C | = | Commercial lanes. |
| G | = | Re-posting duplicate post mile at end of route. |
| L | = | Overlap post mile at beginning of route. |
| S | = | Spur |
| T | = | Temporary connection. |

Post Mile Suffixes - Proposed System

| | | |
|---|---|---|
| A | = | Ordinary post mile marker (Note: This type of post mile marker is presently identified with a blank or no suffix). |

C = PM equation at beginning and end of couplet.
E = PM equation at beginning and end of realignment.
N = PM equation at first and last crossing of county line. (Excludes the intervention of meandering county line, which are identified with the suffixes, X and Y.)
R = PM value at beginning and end of route.
X = PM equation at low value side of break.
Y = PM equation at high value side of break. (Note: Breaks, represented by suffixes, X and Y, occur at meandering county lines, as well as route breaks.

Native Soil Types

LQCL = Liquid Limit > 50, Clay
SACL = Sandy Clay
SICL = Silty Clay
SILT = Silt
SASI = Sandy Silt
CLSI = Clayey Silt
SAND = Sand
PGSA = Poorly Graded Gravel
CLGR = Clayey Gravel
SHAL = Shale
ROCK = Rock

Contract Agency

The contracting agency, such as a City, a County, the State of California, or a private firm.

Contractor

The name of the company who performed the work for the contracting agency.

Date Adopted

This is the date that the section of roadway was adopted by the State. For example, the County of San Diego might have originally constructed a roadway section in 1935, which was later adopted by the State in 1958.

Design Method

CONV = Conventional
FULL = Full Depth

INCR = Incremental
MCHN = Mechanistic
REHB = Rehabilitation
OTHR = Other

Number of Layers

The total number of designed structural layers from the native soil to the pavement surface. Note that Chip Seals and OGAC are considered layers even though they don't contribute structurally.

Layer Number

The first layer is the bottom layer; e.g. imported borrow or aggregate subbase

Layer Type

B = Base
D = Drainage Layer (ATPB)
F = Fabric
P = Asphalt Concrete
Q = Surface (Chip Seal, OGAC)
S = Subbase
T = Soil Stabilized Layer
X = Other

Material Type

| | | |
|---|---|---|
| DGAC | = | Dense Graded Asphalt Concrete |
| OGAC | = | Open Graded Asphalt Concrete |
| RACC | = | Recycled Asphalt Concrete |
| RACH | = | Recycled Asphalt Concrete Hot |
| ARDG | = | Asphalt Rubber Hot Mix-Dense Graded |
| AROG | = | Asphalt Rubber Hot Mix-Open Graded |
| ARGG | = | Asphalt Rubber Hot Mix-Gap Graded |
| SEPX | = | Seal Epoxy |
| SFOG | = | Seal Fog |
| SSLR | = | Seal Slurry |
| SSND | = | Seal Sand |
| SCHP | = | Seal Chip |
| SKPA | = | Skin Patch |
| OS | = | Other Surface |
| ACB | = | Asphalt Concrete Base |
| ATPB | = | Asphalt Treated Permeable Base |
| CTPB | = | Cement Treated Permeable Base |
| LCB | = | Lean Concrete Base |
| CTB | = | Cement Treated Base |
| SCB | = | Soil Cement Base |
| AB | = | Aggregate Base |
| LTB | = | Lime Treated Base |
| OB | = | Other Base |
| ASB | = | Aggregate Subbase |
| OSS | = | Other Soil Stabilization |

Recycle Type

| | | |
|---|---|---|
| AC | = | Reclaimed Asphalt Pavement |
| PC | = | Portland Cement Concrete |
| GL | = | Glass |
| CT | = | Cement Treated Base |
| LT | = | Lean Concrete Base |

Stabilized Soil

| | | |
|---|---|---|
| SSL | = | Lime |
| SSC | = | Cement |
| SSFA | = | Fly Ash |
| SSE | = | Emulsion |
| IB | = | Imported Borrow |

Material Class

| | | |
|---|---|---|
| 100 | = | Class 1 or Type 1 |
| 200 | = | Class 2 or Type 2 |
| 300 | = | Class 3 or Type 3 |
| 400 | = | Class 4 |
| | 010 = | 37.5 mm max. |
| | 020 = | 19.0 mm max. |
| | 030 = | 12.5 mm max. |
| | 040 = | 9.5 mm max. |
| | 050 = | 4.75 mm max. |
| | | 001 Course |
| | | 002 Medium |
| | | 003 Medium Fine |
| | | 004 Fine |
| | | 005 Double |
| 500 | = | Class 5 |
| 600 | = | Class A or Type A |
| 700 | = | Class B or Type B |

Method of Mix

| | | |
|---|---|---|
| B | = | Batch Plant |
| D | = | Dryer Drum |
| O | = | Other |

Drainage Type - ATPB, CTPB, Retrofit Edge Drains

A six- column code to specify the type of drainage for Layer Type "D". For example, the case, "CE304", could specify drainage type "C" with edge drains "E" having outlets that are "3" inches in diameter, spaced "400" feet apart.

Fabric Type

A two-column code to specify the type of fabric for Layer Type "F". For example, the code, "WF", could specify a woven fabric, and the code, "NW", could specify a non woven fabric.

Latitude/Longitude DMS

Degree, Minute, Second

Asphalt Grade

| | | |
|---|---|---|
| MC | = | Medium Curing |
| SC | = | Slow Curing |
| PN | = | Penetration |
| AR | = | Asphalt Residue |
| PB | = | Performance Based |

Asphalt Concrete - Specific Gravity,

Unit weight of AC / Unit weight of water

Asphalt Concrete - Percent Calculated Voids

The "Air-Voids" can be determined knowing the Specific Gravity of the Aggregate and the Asphalt, the density of the compacted sample, and the Asphalt Content.

Asphalt Concrete Modulus

The stress divided by the strain at a designated temperature.

Additives

L = Lime

P = Polymer

R = Crumb Rubber

Temperature

At time of placement, e.g. breakdown rolling

**Field descriptions unique to rehabilitation**

Existing Base - Type

0 = Unknown
1 = Lean concrete
2 = Cement treated
3 = Asphalt concrete
4 = Aggregate Base
5 = All others

Existing AC - Condition

C = Cracking

C1XX = < 3 mm wide (hairline)
C2XX = ≥ 3 mm to 6 mm wide
C3XX = ≥ 7 mm wide
CX1X = Alligator
CX2X = Block
CX3X = Longitudinal
CX4X= Transverse
CXX1 = Generally limited to wheel path or occasional
CXX2 = Widespread
CXX3 = Severe, including potholes

R = Rutting

R1XX = One wheel path
R2XX = Both wheel paths
RX1X = 13 mm to 25 mm deep
RX2X = ≥ 26 mm deep
RXX1 = Depressions without heaving
RXX2 = Heaving or shoving associated with rut

S = Raveling

S1X* = Moderately rough and pitted
S2X* = Severely rough and pitted
SX1* = Abrasion in wheel path
SX2* = Widespread
SX3* = Drip track

B = Bleeding

B1X* = One wheel path
B2X* = Both wheel paths

B3X* = Widespread
BX1* = Slight
BX2* = Moderate
BX3* = Severe

Pavement Deflection

Average 80$^{th}$ Percentile

Milled Depth

The depth from the pavement surface to which the existing material has been removed.

State Contract

N = No, the State was not the contracting agency.
Y = Yes, the State was the contracting agency.

Number of Layers

0 = Only deflections were recorded.
1-9 = The number of designed layers existing over native soil

**Field descriptions unique to maintenance files**

Record Modification

0 = Flexible Pavement

1 = Rigid Pavement

Number of Lanes (Columns 19-20)

The number of lanes in the both direction. (Note: The is the only type of record where the number of lanes in both directions is coded. This is because the PMS file, from which these records have been extracted, has used this coding convention ever since the first PMS survey in 1978. However, in the future, every effort should be made to conform to the standard format as proposed above.

Lane ID (Columns 20-21)

The lane number, where 1 = the lane closet to the median, (Note: As with the "Number Of Lanes," this is the only type of record where this coding convention will be permitted. Again, in the future, every effort should be made to conform to the standard format as proposed above.

Date

The date of the PMS Survey. — use an E prefix

Ride Score

(Summation of deflections ≥3 mm) (Vehicle Factor) (50) (Odometer Length)

PSI = Presently Serviceability Index

A subjective rating system identifying pavement condition 0=impassible, 5=perfect

Cost Series

The annual cost to maintain the section of highway, on a "per lane" and "per mile" basis. It pertains only to the cost of traveled pavement. In other words, it excluded the cost of any medians or shoulders. The term, 0, refers to last year. The term, -1, refers to one year prior to last year, The term -2, refers to two years prior to last year.

Pavement Condition:

*Load Associated Cracks*

ANN* = Fatigue Cracks (Alligator Cracks) Inside Wheel-Paths--Percent of Alligator Cracks in Wheel Path(s)

BNN* = Interconnected Alligator Cracks In Either Wheel Path--Percent of Alligator Cracks in Wheel Path(s)

CNN* = Identify Cracking Outside Wheel Path--Percent of Alligator Cracks Outside Wheel Paths

*Non-Load Associated Cracks*

DNN* = Block Cracks--Severity--Percent Of Lane Area

TNN* = Transverse Cracks--Severity ‡ --Number Per 30 m Station†

LNN* = Longitudinal Cracks--Severity‡--Lineal Feet Per 30 m Station•

‡ Severity: 1=<3 mm 2=3 mm to 6 mm 4=>7 mm

†Number Per 30 m Station: 1 = 1 Crack/Station, 2 = 2 Cracks per Station... 9 = 9 or more Cracks/Station

•Lineal Meters Per 30 m Station: 1=1 to 30 m/Station, 2 = 31 to 60 m/Station.... 9=241 or more m/Station

*Raveling and Weathering*

RFNN = Raveling-Fine or Moderate--Percent of Lane Area

RCNN = Raveling-Course or Severe--Percent of Lane Area

*Drip Track Raveling*

EN** = Drip Track Raveling Caused by Oil and Gas Drippings-Extent of Raveling Each Section. 1 = 1 Occurrence Per Lane, 2 = 2 Per Lane... 9 = 9 or more Per Lane

*Rutting*

FNN* = Ruts ≥ 20 mm--Percent of Lane Length

*Patching*

PANN = Patching-Ride Condition+ --Percent Of Lane Area

+Ride Condition: G = Good, Does Not Materially Affect Ride

F = Fair, Affects Ride Quality To Some Extent

P = Poor, Ride Quality Is Severely Affected

*Remark On Cause*

Remark on the cause for maintaining the pavement, as for example, "Skid Number = 23," or "1982 PMS Survey".

**Proposed Format for New Construction**

| Field | Start Column | Format |
|---|---|---|
| User ID | 01 | AA |
| Record ID | 03 | AAA |
| Record Modification | 06 | A |
| State | 07 | AA |
| District | 09 | NN |
| County | 11 | AAA |
| Route | 14 | NNN |
| Route Suffix | 17 | A |
| Direction | 18 | N |
| Number of Lanes | | |
| Direction = L | 19 | N |
| Direction = R | 20 | N |
| Lane ID | | |
| Permanent | 21 | A |
| Temporary | 22 | A |
| Date (Mo/Yr) | 23 | ANNNN |
| Section identification | | |
| From-Post Mile Prefix | 28 | A |
| Post Mile | 29 | NNN.NNN |
| Post Mile Suffix | 36 | A |
| To-Post Mile Prefix | 37 | A |
| Post Mile | 38 | NNN.NNN |
| Post Mile Suffix | 45 | A |
| Format option #1 | | |
| From County Mile Prefix | 46 | A |
| County Mile | 47 | NNN.NNN |
| County Mile Suffix | 54 | A |
| To County Mile Prefix | 55 | A |
| County Mile | 56 | NNN.NNN |
| County Mile Suffix | 63 | A |
| Format option #2 | | |
| From County Odom Reading | 46 | ANNN.NNA |
| To County Odom Reading | 54 | ANNN.NNA |
| Filler | 62 | XX |

| | | |
|---|---|---|
| Format option #3 | | |
| Filler | 46 | X |
| Sequence of Record | 47 | NNNNNN.N |
| Filler | 56 | 8X |
| Expenditure authorization or contract number | 64 | NNNNNN |
| Native Soil | 70 | AAAA |
| R-Value | 74 | NN |
| Contracting Agency | 76 | 20A |
| Contractor | 96 | 20A |
| Date State Adopted | 116 | NNNN |
| Design Method | 120 | AAAA |
| Design TI | 124 | NN.N |
| Filler | 128 | XX |
| Number of Layers | 130 | NN |
| LAYER DESIGN | | |
| Layer Number | 132 | NN |
| Layer Type | 134 | A |
| Material Type | 135 | AAAA |
| Material Class | 139 | AAA |
| Thickness (mm) | 142 | NNN |
| R-Value or Stabilometer Value | 145 | NN |
| Gravel Factor | 147 | A.AA |
| Method of Mix | 151 | A |
| Fabric Type | 152 | AA |
| AGGREGATE SOURCE | | |
| Latitude (DMS) | 154 | NNN-NN-NN |
| Longitude (DMS) | 163 | NNN-NN-NN |
| Recycled Material % | 172 | NN |
| Recycle Type | 174 | NN |
| Filler | 176 | XX |
| Grade Asphalt | 178 | AAANNNNN |
| Viscosity | 186 | NNNNN |
| Bituminous Ratio (%) | | |
| Design | 191 | NN.N |
| Used | 195 | NN.N |
| Specific Gravity | 199 | N.NN |
| Moisture Content % | 203 | NN.N |

| | | |
|---|---|---|
| Maximum Density (kg/m$^3$) | 207 | NNNN |
| In-Place Density (kg/m$^3$) | 211 | NNNN |
| Relative Compaction % | 215 | NN.N |
| Stiffness (MPa) | 219 | NNNN |
| Test Temp (C) | 223 | NNN |
| First Additive | | |
| Type | 226 | AA |
| Percent | 228 | NN.N |
| Second Additive | | |
| Type | 232 | AA |
| Percent | 234 | NN.N |
| Lay Temperature (C) | | |
| Ambient | 238 | NN |
| Mix | 240 | NNN |
| Filler | 243 | X |
| Comments | 244 | 60A |

**Record Example For New Construction**

| | |
|---|---|
| User Id | TM |
| Record ID | 001 |
| Record Modification | 0 |
| State | CA |
| District | 12 |
| County | ORA |
| Route | 55 |
| Number of Lanes | 22 |
| Direction | L |
| Lane ID | 11 |
| Date Constructed | C078 |
| Post Mile to | R017.000* |
| Post Mile | R024.000* |
| County Mile to | F016.00B |
| County Mile | F023.00B |
| Expenditure Authorization | 123454 |
| Native Soil | |
| R-Value | 44 |
| Type | SAND |
| Contracting Agency | STATE OF CALIFORNIA |
| Contractor | KAISER INC. |
| Date State Adopted | 1258 |
| Design Method | CONV |
| Design TI | 10.0 |
| Number of Layers | 3 |
| Layer Number | 1 |
| Layer Type | B |
| Material Type | AB |
| Material Class | 220 |
| Thickness (mm) | 150 |
| R-Value | 78 |
| Gravel Factor | 1.1 |
| AGGREGATE SOURCE | |
| Latitude | 52-30-45 |
| Longitude | 122-45-34 |
| Moisture Content (90) | 4.6 |

| | |
|---|---|
| Maximum Density (kg/m$^3$) | 2380 |
| In-place Density (kg/m$^3$) | 2260 |
| Relative Compaction (%) | 95.0 |
| Lay Temperature (C) | 40 |
| Layer Number | 2 |
| Layer Type | D |
| Material Type | ATPB |
| Thickness (mm) | 075 |
| Gravel Factor | 1.4 |
| Method of Mix | D |
| Drainage Type | CE0610 |
| AGGREGATE SOURCE | |
| Latitude | 52-30-45 |
| Longitude | 122-45-34 |
| Specific Gravity | 2.78 |
| Grade Asphalt | AR-8000 |
| Grade Viscosity | 8000 |
| Btm Ratio, % | |
| Design | 2.5 |
| Used | 2.5 |
| Lay Temperature (C) | |
| Ambient | 30 |
| Mix | 132 |
| Layer Number | 3 |
| Layer Type | P |
| Material Type | DGAC |
| Material Class | 3 |
| Thickness (mm) | 075 |
| Stabilometer-Value | 37 |
| Gravel Factor | 1.9 |
| Method of Mix | D |
| AGGREGATE SOURCE | |
| Latitude | 52-30-45 |
| Longitude | 122-45-34 |
| Specific Gravity | 2.81 |
| Grade Asphalt | PBA.3 |
| Viscosity | 3000 |
| Btm Ratio, % | |

| | |
|---|---|
| Design | 5.4 |
| Used | 5.5 |
| Maximum Density (kg/m$^3$) | 2440 |
| In-place Density (kg/m$^3$) | 2340 |
| Relative Compaction | 95.9 |
| Lay Temperature (C) | |
| Ambient | 29 |
| Mix | 138 |

**Proposed Format For Rehabilitation**

| Field | Start Column | Format |
|---|---|---|
| User ID | 01 | AA |
| Record ID | 03 | NNN |
| Record Modification | 06 | N |
| State | 07 | AA |
| District | 09 | NN |
| County | 11 | AAA |
| Route | 14 | NNN |
| Route Suffix | 17 | A |
| Direction | 18 | A |
| Number of Lanes | | |
| Direction = L | 19 | N |
| Direction = R | 20 | N |
| Lane ID | | |
| Permanent | 21 | A |
| Temporary | 22 | N |
| Date (Mo/Yr) | 23 | NNNN |
| Section Identification | | |
| From Post Mile Prefix | 27 | A |
| Post Mile | 28 | NNN.NNN |
| Post Mile Suffix | 35 | A |
| To Post Mile Prefix | 36 | A |
| Post Mile | 37 | NNN.NNN |
| Post Mile Suffix | 44 | A |
| Format option #1 | | |
| From County Mile Prefix | 45 | A |
| County Mile | 46 | NNN.NNN |
| County Mile Suffix | 53 | A |
| To County Mile Prefix | 54 | A |
| County Mile | 55 | NNN.NNN |
| County Mile Suffix | 62 | A |
| Format option #2 | | |
| Filler | 45 | X |
| From County Odom Reading | 46 | ANNN.NNA |
| To County Odom Reading | 54 | ANNN.NNA |
| Filler | 62 | XX |

| | | |
|---|---|---|
| Format option #3 | | |
| Filler | 45 | X |
| Sequence Of Record | 46 | NNNNNNN |
| Filler | 53 | 11X |
| Expend. Auth. or Cont. No. | 64 | NNNNNN |
| Deflection | | |
| Average 80 Percentile (mm) | 70 | N.NN |
| Remarks | 74 | 124N |
| Existing Subbase | | |
| Thickness (mm) | 197 | NNN |
| Existing Base | | |
| Thickness (mm) | 200 | NNN |
| Type | 203 | N |
| Existing AC | | |
| Thickness (mm) | 204 | NNN |
| Condition 1. | 207 | ANNN |
| 2. | 211 | ANNN |
| 3. | 215 | ANNN |
| 4. | 219 | ANNN |
| 5. | 223 | ANNN |
| 6. | 227 | ANNN |
| 7. | 231 | ANNN |
| Milled Depth (mm) | 235 | NNN |
| State Contract | 238 | A |
| Contractor | 239 | 20A |
| Design Method | 259 | AAAA |
| Design TI | 263 | NN.N |
| Filler | 267 | 31X |
| Number of Layers | 298 | NN |
| Layer Number | 300 | NN |
| Layer Type | 302 | A |
| Materials Type | 303 | AAAAA |
| Material Class | 308 | A |
| Thickness (mm) | 309 | NNN |
| R-Value or Stabilometer Value | 312 | NN |
| Gravel Factor | 314 | N.N |
| Method Of Mix | 317 | A |
| Drainage Type | 318 | AAAAAA |

| | | |
|---|---|---|
| Fabric Type | 324 | AA |
| AGGREGATE SOURCE | | |
| Latitude (DMS) | 326 | NNN-NN-NN |
| Longitude (DMS) | 335 | NNN-NN-NN |
| Recycled Material (%) | 344 | NN |
| Recycled Type | 346 | NN |
| Specific Gravity | 348 | N.NN |
| Grade Asphalt | 352 | AA |
| Viscosity | 354 | NNNNN |
| Bituminous Ratio (%) | | |
| Design | 359 | NN.N |
| Used | 363 | NN.N |
| Water Content % | 367 | N.NN |
| Maximum Density ($kg/m^3$) | 371 | NNNN |
| In-Place Density ($kg/m^3$) | 375 | NNNN |
| Relative Compaction (%) | 379 | NN.N |
| Stiffness (MPa) | 383 | NNNN |
| Additive (First) | | |
| Type | 387 | AA |
| Percent | 389 | NN.NN |
| Additive (Second) | | |
| Type | 394 | AA |
| Percent | 396 | NN.NN |
| Temperature (C) | | |
| Ambient | 401 | NN |
| Mix | 403 | NNN |
| Filler | 406 | XX |
| Comments | 408 | 60A |

**Record Example For Rehabilitation**

| | |
|---|---|
| User ID | TM |
| Record | 002 |
| Record Modification | 0 |
| State | CA |
| District | 07 |
| County | LA* |
| Route | 072 |
| Route Suffix | * |
| Direction | R |
| Number of Lanes | 33 |
| Lane ID | J2 |
| Date Rehabilitated | 1082 |
| Section identification | |
| From-Post Mile | R017.000* |
| To-Post Mile | R024.000* |
| Or, From-County Mile | F016.000C |
| To-County Mile | F023.000C |
| Expend. Auth. | 123454 |
| Deflection, (mm) | |
| Average 80 Pct. Defl. | 0.75 |
| Existing Subbase | |
| Thickness (mm) | *** |
| Existing Base | |
| Thickness (mm) | *** |
| Type | 0 |
| Existing AC | |
| Thickness (mm) | 110 |
| Condition | C211 |
| | C131 |
| | R211 |
| | **** |
| | **** |
| | **** |
| | **** |
| Milled Depth (mm) | 030 |
| State Contract | Y |

| | |
|---|---|
| Contractor | TOUGHGUY & SON |
| Design Method | REHB |
| Design TI | 10.5 |
| Number of Layers | 01 |
| Layer Number | 01 |
| Layer Type | P |
| Material Type | DGAC |
| Material Class | 622 |
| Thickness (mm) | 150 |
| Stabilometer Value | 38 |
| Gravel Factor | 1.9 |
| Method of Mix | D |
| AGGREGATE SOURCE | |
| Latitude | 52-35-26 |
| Longitude | 192-45-35 |
| Specific Gravity | 2.72 |
| Grade Asphalt | PBA3 |
| Viscosity | 4400 |
| Btn Ratio | |
| Design | 5.1 |
| Used | 5.2 |
| Moisture content, % | 0.72 |
| Maximum Density,kg/$m^3$ | 2410 |
| In Place Density, kg/$m^3$ | 2380 |
| Relative Compaction, % | 98.8 |
| Stiffness | *** |
| Temperature | |
| Ambient | 29 |
| Mix | 121 |
| Comments | Some aggregate segregation between R17.00 and R17.08 |

**Proposed Format for Maintenance Records**

| Field | Start Column | Format |
|---|---|---|
| User ID | 01 | AA |
| Record ID | 03 | AAA |
| Record Modification | 06 | A |
| State | 07 | AA |
| District | 09 | NN |
| County | 11 | AAA |
| Route | 14 | NNN |
| Route Suffix | 17 | A |
| Direction | 18 | A |
| Number of Lanes | | |
| Direction = L | 19 | N |
| Direction = R | 20 | N |
| Lane ID | | |
| Permanent | 21 | A |
| Temporary | 22 | A |
| Date (Mo/Yr) | 23 | NNNN |
| Prefix | 27 | A |
| Section Identification | | |
| From-Post Mile Prefix | 28 | A |
| Post Mile | 29 | NNN.NNN |
| Post Mile Suffix | 36 | A |
| To-Post Mile Prefix | 37 | A |
| Post Mile | 38 | NNN.NNN |
| Post Mile Suffix | 45 | A |
| Format option #1 | | |
| From-County Mile Prefix | 46 | A |
| County Mile | 47 | NNN.NN |
| County Mile Suffix | 53 | A |
| To-County Mile Prefix | 54 | A |
| County Mile | 55 | NNN.NN |
| County Mile Suffix | 61 | A |
| Filler | 62 | XX |
| Format option #2 | | |
| Filler | 46 | X |

| | | |
|---|---|---|
| From County Odom Reading | 47 | NNN.NNN |
| Filler | 54 | 2X |
| To County Odom Reading | 56 | NNN.NNN |
| Filler | 63 | X |
| Format option #3 | | |
| Filler | 46 | X |
| Sequence of Record | 47 | NNNNNNN |
| Filler | 54 | 10X |
| Expend. Auth | 64 | NNNNNN |
| Remark On Cause | 70 | 24A |
| Existing Subbase | | |
| Thickness (mm) | 94 | NNN |
| Existing Base | | |
| Thickness (mm) | 97 | NNN |
| Type | 100 | N |
| | | |
| Existing Pavement Surface | | |
| Condition 1. | 101 | ANNN |
| 2. | 105 | ANNN |
| 3. | 109 | ANNN |
| 4. | 113 | ANNN |
| 5. | 117 | ANNN |
| 6. | 121 | ANNN |
| 7. | 125 | ANNN |
| Filler | 129 | 8X |
| State Contract | 137 | A |
| Contractor | 138 | 20A |
| Number of Layers | 158 | NN |
| Layer Number | 160 | NN |
| Layer Type | 162 | A |
| Material Type | 163 | AAAA |
| Material Class | 169 | A |
| Thickness (mm) | 170 | NNN |
| R-Value/S-Value | 173 | NN |
| Gravel Factor | 175 | N.N |
| Method of Mix | 178 | A |
| Drainage Type | 179 | AAAAAA |
| Fabric Type | 185 | AA |

| | | |
|---|---|---|
| AGGREGATE SOURCE | | |
| Latitude (DMS) | 187 | NNN-NN-NN |
| Longitude (DMS) | 196 | NNN-NN-NN |
| Recycled (%) Material | 205 | NN |
| Recycled Type | 207 | NN |
| Filler | 209 | 2X |
| Grade Asphalt | 211 | AA |
| Viscosity | 213 | NNNNN |
| Bituminous Ratio (%) | 217 | NN.N |
| Specific Gravity | 221 | N.NNN |
| Maximum Density (kg/m$^3$) | 226 | NNNN |
| In-Place Density (kg/m$^3$) | 230 | NNNN |
| Relative Compaction | 234 | NN.N |
| Stiffness (MPa) | 238 | NNNN |
| First Additive | | |
| Type | 242 | AA |
| Percent | 244 | NN.NN |
| Second Additive | | |
| Type | 249 | AA |
| Percent | 251 | NN.NN |
| Lay Temperature (C) | | |
| Ambient | 256 | NN |
| Mix | 258 | NNN |
| Filler | 261 | X |
| Comments | 262 | 60A |

**Record Example of Maintenance Records**

| | |
|---|---|
| User ID | TM |
| Record ID | 003 |
| Record Modification | 0 |
| State | CA |
| District | 07 |
| County | LA |
| Route | 55 |
| Direction | R |
| Number Of Lanes | 22 |
| Lane ID | J2 |
| Date Maintained | 1083 |
| Post Mile to | R017.000* |
| Post Mile | R017.500* |
| County Odom to | 016.000 |
| County Odom | 016.500 |
| Expend. Auth | 654321 |
| Remark on Cause | 1984 Survey |
| Existing Subbase | |
| Thickness | *** |
| Existing Base | |
| Thickness | *** |
| Type | 0 |
| Existing Pavement | |
| Thickness | *** |
| Condition | A20* |
| | T12* |
| | L11* |
| | RF50 |
| | PG10 |
| | **** |
| | **** |

| | |
|---|---|
| State Contract | N |
| Contractor | In House |
| Number of Layers | 1 |
| Layer Number | 1 |
| Layer Type | Q |
| Material Type | OGAC |
| Thickness (mm) | 025 |
| Method of Mix | B |
| AGGREGATE SOURCE | |
| Latitude | 52-35-26 |
| Longitude | 192-45-35 |
| Asphalt Grade | PB6 |
| Viscosity | 8000 |
| Btm Ratio | 5.5 |

File - Historical Surface Performance

Information for this file exists in the PMS file. A format for a file is provided here but the data could be made accessible form the PMS file. The relative positions of the various fields is patterned after the record format as defined in the report "Development of the California Pavement Management System", "Volume 2 - Manual of Rating Instructions" (13). It is appropriate that consideration be given to uniformity so that whatever decisions are made regarding site location for the new construction, the rehabilitation, and the maintenance files. will be implemented in the Historical Surface Performance File (or the PMS file if it is to be accessed as a data feedback file).

**Proposed Format for Historical Surface Performance**

| Field | Start column | Format |
|---|---|---|
| User ID | 01 | AA |
| Record ID | 03 | NNN |
| Record Modification | 06 | N |
| State | 07 | AA |
| District | 09 | NN |
| County | 11 | AAA |
| Route | 14 | NNN |
| Route Suffix | 17 | A |
| Direction | 18 | A |
| Number of Lanes | | |
| Direction = L | 19 | N |
| Direction = R | 20 | N |
| Lane ID | | |
| Permanent | 21 | A |
| Temporary | 22 | N |
| Date (Mo/Yr) | 23 | NNNN |
| Section Identification | | |
| From Post Mile Prefix | 27 | A |
| Post Mile | 28 | NNN.NNN |
| Post Mile Suffix | 35 | A |
| To Post Mile Prefix | 36 | A |
| Post Mile | 37 | NNN.NNN |
| Post Mile Suffix | 44 | A |
| Format option #1 | | |
| From County Mile Prefix | 45 | A |
| County Mile | 46 | NNN.NNN |
| County Mile Suffix | 53 | A |
| To County Mile Prefix | 54 | A |
| County Mile | 55 | NNN.NNN |
| County Mile Suffix | 62 | A |

| | | |
|---|---|---|
| Format option #2 | | |
| Filler | 45 | X |
| From County Odom Reading | 46 | NNN.NNN |
| Filler | 53 | 2X |
| To County Odom Reading | 55 | NNN.NNN |
| Filler | 62 | X |
| | | |
| Format option #3 | | |
| | | |
| Filler | 45 | X |
| Sequence Of Record | 46 | NNNNNNN |
| Filler | 53 | 9X |
| Rain (Annual to date) (mm) | 62 | NNNN |
| ADT | 66 | NNNNNNN |
| Posted Speed | 73 | NN |
| Ride Score | 75 | NN |
| PSI | 77 | N.N |
| Cost - 0 | 80 | NNNNNN |
| Cost - 1 | 86 | NNNNNN |
| Cost - 2 | 92 | NNNNNN |
| Filler | 98 | 4X |
| FLEXIBLE PAVEMENT | 102 | 'FLEX' |
| Alligator Cracks | | |
| A | 106 | 'A'NN |
| B | 109 | 'B'NN |
| C | 112 | 'C'NN |
| Block Cracks | 115 | 'D' |
| Extent | 116 | NN |
| Transverse Cracks | 118 | 'T' |
| Severity | 119 | N |
| Extent | 120 | N |
| Longitudinal Cracks | 121 | 'L' |
| Severity | 122 | N |
| Extent | 123 | N |
| Filler | 124 | XX |
| Ravel and Weather | 126 | 'R' |
| Severity | 127 | A |
| Extent | 128 | NN |

| | | |
|---|---|---|
| Filler | 130 | X |
| Drip Track Ravel | 131 | 'E' |
| Extent | 132 | N |
| Rutting | 133 | 'F' |
| Extent | 134 | NN |
| Patching | 136 | 'P' |
| Condition | 137 | A |
| Extent | 138 | NN |
| Surface Type | 140 | AAAA |
| Filler | 144 | 8X |

## Record Example for Historical Surface Performance

| | |
|---|---|
| User ID | TM |
| Record ID | 004 |
| Record Modification | 0 |
| State | CA |
| District | 07 |
| County | LA* |
| Route | 155* |
| Direction | L |
| Number of Lanes | 04 |
| Lane ID | 01 |
| Date Observed | I0576 |
| Post Mile to | R017.000* |
| Post Mile | R024.000* |
| Sequence Of Record | 0005036 |
| Rain (Annual to date) (mm) | 762 |
| ADT | 0012000 |
| Posted Speed | 55 |
| Ride Score | 040 |
| Cost - 0 | 1500 |
| Cost - 1 | 2000 |
| Cost - 2 | 500 |
| FLEXIBLE PAVEMENT | 'FLEX' |
| Alligator Cracks | |
| A | A20 |
| B | B15 |
| C | *** |
| Block Cracks | D |
| Extent | 05 |
| Transverse Cracks | T |
| Severity | 2 |
| Extent | 5 |
| Ravel and Weather | R |
| Severity | F |
| Extent | 25 |
| Drip Track Ravel | E |
| Extent | 5 |

| | |
|---|---|
| Rutting | F |
| Extent | 00 |
| Patching | P |
| Severity | G |
| Extent | 20 |
| Surface Type | DGAC |

Available Catalogued Data Sets On Mainframe -- TSL
TMMLL.TM0040.FLEX.PMS100.FY78
TMMLL.TM0040.FLEX.PMS100.FY80
TMMLL.TM0040.FLEX.PMS100.FY82
TMMLL.TM0040.FLEX.PMS100.FY84
TMMLL.TM0040.FLEX.PMS100.FY85
TMMLL.TM0040.FLEX.PMS100.FY87
TMMLL.TM0040.FLEX.PMS100.FY89
TMMLL.TM0040.FLEX.PMS100.FY92

DCB=(RECFB=FB,LRECL=140,BLKSIZE=14000)

```
***** BEGIN JCL EXAMPLE ************************************

//xxxxxxxx JOB (xxxxxx,xxxx,xxxxx,xxxxx),xxxxx-xxx-xxxx,REGION=2000K
//*MAIN    LINES=(5,C),CLASS=A
//*
//STEP111A EXEC TMMLLPLI
//SYSPRINT DD SYSOUT=N
//SYSIN    DD DSN=TMMLL.PROGRAM.SELECT.PLI.R0300,DISP=SHR
//*
//STEP111B EXEC TMMLLLNK
//*
//STEP111C EXEC TMMLLRUN,TIME=(0,30)
//SYSPRINT DD SYSOUT=1
//DDOUTPUT DD DSN=&&SELECT,DISP=(NEW,PASS),
//         UNIT=SYSDA,SPACE=(CYL,(2,2)),
//         DCB=(RECFM=FB,LRECL=300,BLKSIZE=12900)
//DDA      DD DSN=TMMLL.TM0040.FLEX.PMS100.FY78,DISP=SHR
//DDB      DD DSN=TMMLL.TM0040.FLEX.PMS100.FY80,DISP=SHR
//DDC      DD DSN=TMMLL.TM0040.FLEX.PMS100.FY82,DISP=SHR
//DDD      DD DSN=TMMLL.TM0040.FLEX.PMS100.FY84,DISP=SHR
//DDE      DD DSN=TMMLL.TM0040.FLEX.PMS100.FY85,DISP=SHR
//DDF      DD DSN=TMMLL.TM0040.FLEX.PMS100.FY87,DISP=SHR
//DDG      DD DSN=TMMLL.TM0060.DIST11,DISP=SHR
//DDH      DD DSN=TMMLL.TM0061.PYPSCAN,DISP=SHR
//LASTFILE DD *
DDH
//DDSELECT DD *
        IMP086              7.000    7.500
//*
//STEP2222 EXEC SAS,TIME=(0,10),COND=(2,LT)
//FT11F001 DD SYSOUT=N
//FT12F001 DD SYSOUT=2
//DDINPUT  DD DSN=&&SELECT,DISP=(OLD,DELETE)
//DDOUTPUT DD DSN=&&EDITED,DISP=(NEW,PASS),
//         UNIT=SYSDA,SPACE=(CYL,(1,1)),
//         DCB=(RECFM=FB,LRECL=300,BLKSIZE=12900)
//SYSIN    DD DSN=TMMLL.PROGRAM.EDITED.SAS.R0300,DISP=SHR

***** END JCL EXAMPLE **************************************
```

The following is a brief description of the more important DD-names used in the above JCL example. Other DD-names should be self-explanatory.

**SYSIN** In STEP111A it contains the PLI program. (Shown in APPENDIX II.)
In STEP2222 it contains the SAS program. (Shown in APPENDIX III.)

**LASTFILE** Contains the last ddname of the file(s) from which the records are to be selected.
Cols 01-03 = Last ddname in sequence of files.

**DDSELECT** Contains the requested roadway section(s). The program is written to accommodate a retrieval request for 100 roadway sections per job.
Cols 11-13 = County.
Cols 14-16 = Route.
Cols 28-34 = Begin PM Value.
Cols 37-43 = End PM Value.
The example has only one selection or retrieval request for a section of highway in IMPerial County, Route 86, from post mile 7.0 to 7.5.

**DDOUTPUT** In STEP111C it contains the selected records in their "raw" form.
In STEP2222 it contains the edited records of the selected records from STEP111C.
Further processing of the edited records will probably be required, if they are to be shown in a report for management.

```
//STEP3333 EXEC SAS,TIME=(0,10),COND=(2,LT)
//FT11F001 DD SYSOUT=N
//FT12F001 DD SYSOUT=3
//DDINPUT  DD DSN=&&EDITED,DISP=(OLD,DELETE)
//SYSIN    DD *

********** BEGIN EXAMPLE OF A SAS REPORT PROGRAM **********************;
DATA TM0040 (DROP=MONTH P_SPEED PSI D_SEQ TYPE_REM REMARK)
     TM0060 (KEEP=REC_TYPE DISTRICT COUNTY ROUTE RTE_SFX PM_A PM_B
             DRCTN LANE YEAR PRFX_A PRFX_B D_SEQ TYPE_REM REMARK);

     INFILE DDINPUT;  INPUT
     @   1 REC_TYPE   $CHAR6.          @   9 DISTRICT   $CHAR2.
     @  11 COUNTY     $CHAR3.          @  14 ROUTE      $CHAR3.
     @  17 RTE_SFX    $CHAR1.          @  18 DRCTN      $CHAR1.
     @  19 TOT_LANE   $CHAR2.          @  21 LANE       $CHAR2.
     @  23 MONTH      $CHAR2.          @  25 YEAR       $CHAR2.
     @  27 PRFX_A     $CHAR1.          @  28 PM_A       $CHAR7.
     @  36 PRFX_B     $CHAR1.          @  37 PM_B       $CHAR7. @;

     IF REC_TYPE EQ 'TM0040'  THEN DO;  INPUT
     @  63 RAIN       $CHAR3.          @  66 ADT        $CHAR7.
     @  73 P_SPEED    $CHAR2.          @  75 RIDE_SCR   $CHAR3.
     @  78 PSI        $CHAR2.
     @  80 COST_0     $CHAR6.          @  86 COST_1     $CHAR6.
     @  92 COST_2     $CHAR6.          @ 106 ALLIG_A    $CHAR2.
     @ 108 ALLIG_B    $CHAR2.          @ 110 ALLIG_C    $CHAR1.
     @ 111 BLOCK      $CHAR1.          @ 113 TRANS_SV   $CHAR1.
     @ 115 TRANS_EX   $CHAR1.          @ 116 LONG_SV    $CHAR1.
     @ 117 LONG_EX    $CHAR1.          @ 120 RAVEL_SV   $CHAR1.
     @ 121 RAVEL_EX   $CHAR2.          @ 124 DRIP       $CHAR1.
     @ 125 RUTTING    $CHAR2.          @ 127 PATCH_CD   $CHAR1.
     @ 128 PATCH_EX   $CHAR2.          @ 130 SHLDR_CD   $CHAR1.;
     OUTPUT TM0040;  RETURN;  END;

     IF REC_TYPE EQ 'TM0060'  THEN DO;
     INPUT  @ 64 D_SEQ  $CHAR1.      @ 67 TYPE_REM  $CHAR4.
            @ 72 REMARK $CHAR40.;
     OUTPUT TM0060;  RETURN;  END;

     IF REC_TYPE EQ 'TM0061'  THEN DO;
     INPUT  @ 67 REMARK $CHAR40.;    REC_TYPE = 'TM0060';
     OUTPUT TM0060;  RETURN;  END;

***** 01 ***************************************************************;
PROC SORT    DATA=TM0040;
     BY DISTRICT COUNTY ROUTE RTE_SFX PM_A
        DRCTN LANE PRFX_A PRFX_B YEAR;

***** 02 ***************************************************************;
PROC PRINT   DATA=TM0040  UNIFORM;  ID DRCTN;
     BY REC_TYPE DISTRICT COUNTY ROUTE RTE_SFX PM_A PM_B;  PAGEBY PM_B;

***** 03 ***************************************************************;
PROC SORT    DATA=TM0060;
     BY DISTRICT COUNTY ROUTE RTE_SFX PM_A
        DRCTN LANE PRFX_A PRFX_B YEAR D_SEQ;

***** 04 ***************************************************************;
PROC PRINT   DATA=TM0060  UNIFORM;  ID DRCTN;
     BY REC_TYPE DISTRICT COUNTY ROUTE RTE_SFX PM_A PM_B;  PAGEBY PM_B;

********** END EXAMPLE OF A SAS REPORT PROGRAM **********************;
```

## PLI Search And Select Program

The following is the PLI program for the JCL example.

```
***** BEGIN PLI SELECTION PROGRAM ************************************

*PROCESS NOOPTIONS OFFSET NOXREF;
MAIN: PROC OPTIONS(MAIN);  DEFAULT
      RANGE (A:B,D:E,G:Z)  FIXED BIN  VALUE (FIXED BIN (31)),
      RANGE (F)            FLOAT BIN  VALUE (FLOAT BIN (53));

      ON ENDFILE (DDFILES) END_DDFILES = 1;
      ON ENDFILE (DDCARDS) END_DDCARDS = 1;
      ON ENDFILE (DDIN)    END_DDIN = 1;
      ON CONVERSION    BEGIN;
                       PUT EDIT ('CONVERSION  :', C_REC)
                               (SKIP, A, A(62));
                       CALL PLIRETC(31);  GOTO Z99;
                       END;

      DCL DDFILES FILE STREAM INPUT;
      DCL DDCARDS FILE STREAM INPUT;
      DCL DDIN    FILE RECORD INPUT;
      DCL DDOUT   FILE STREAM OUTPUT;

      OPEN FILE (DDFILES)  TITLE ('LASTFILE');
      OPEN FILE (DDCARDS)  TITLE ('DDSELECT');
      OPEN FILE (DDOUT)    TITLE ('DDOUTPUT');

      DCL C_IDENT(26)      CHAR(1) INITIAL
                           ('A','B','C','D','E','F','G','H','I','J',
                            'K','L','M','N','O','P','Q','R','S','T',
                            'U','V','W','X','Y','Z'),
          C_REC            CHAR(300)   VARYING,
          C_SAVE           CHAR(10)    VARYING,
          C_LAST_DD        CHAR(3),
          C_PMA            CHAR(7),
          C_PMB            CHAR(7),
          CC               CHAR(3),
          COUNTY(100)      CHAR(3),
          ROUTE(100),
          PMA(100),
          PMB(100),
          P_PMA(100)       PIC 'ZZ9.V999',
          P_PMB(100)       PIC 'ZZ9.V999',
          ONCHAR           BUILTIN;

     END_DDFILES = 0;
     END_DDCARDS = 0;
     END_DDIN = 0;

     GET FILE(DDFILES) EDIT(C_LAST_DD) (SKIP, A(3));
     IF END_DDFILES = 1  THEN DO; CALL PLIRETC(32); GOTO Z99; END;
     DO J = 1 TO 26;
     IF C_LAST_DD = 'DD'||C_IDENT(J)  THEN GOTO A00;
     END;
     CALL PLIRETC(33); GOTO Z99;

A00: CLOSE FILE (DDFILES);
     JJ = 0;
A01: GET FILE(DDCARDS) EDIT(CC, RR, F_A, F_B)
     (SKIP, COL(11), A(3), F(3), COL(28), F(7), X(2), F(7));
     IF END_DDCARDS = 1  THEN GOTO A06;

     IF CC = '  '  THEN DO;
        CALL PLIRETC(35);  GOTO Z99;  END;
     IF RR <= 0  |  RR >= 1000  THEN DO;
        CALL PLIRETC(36);  GOTO Z99;  END;
     IF F_A < 0.0  |  F_A >= 1000.0  THEN DO;
```

```
         CALL PLIRETC(37);  GOTO Z99;  END;
      IF F_B < 0.0  |  F_B >= 1000.0  THEN DO;
         CALL PLIRETC(38);  GOTO Z99;  END;

      AA = 1000.0 * F_A + 0.5;
      BB = 1000.0 * F_B + 0.5;
      IF AA > BB THEN DO;
         SAVE = AA;
         AA = BB;
         BB = SAVE;
         END;

      IF JJ = 0  THEN GOTO A05;
      J = 1;
A02:  K  = J;
      KK = JJ;

      DO J = K TO KK;
      IF RR ¬= ROUTE(J)   THEN GOTO A04;
      IF CC ¬= COUNTY(J)  THEN GOTO A04;
      IF AA > PMB(J)      THEN GOTO A04;
      IF BB < PMA(J)      THEN GOTO A04;

      IF AA >= PMA(J)  &  BB <= PMB(J)  THEN GOTO A01;
      IF AA <= PMA(J)  &  BB >= PMB(J)  THEN GOTO A03;

      IF BB <= PMB(J)  THEN DO;  BB = PMB(J);  GOTO A03;  END;
      IF AA >= PMA(J)  THEN DO;  AA = PMA(J);  GOTO A03;  END;
      CALL PLIRETC(39);  GOTO Z99;

A03:  JJ = JJ - 1;
      IF J = KK THEN GOTO A05;
      DO M = J TO JJ;
      N = M + 1;
      COUNTY(M) = COUNTY(N);
      ROUTE(M)  = ROUTE(N);
      PMA(M)    = PMA(N);
      PMB(M)    = PMB(N);
      END;
      GOTO A02;
A04:  END;

A05:  JJ = JJ + 1;
      IF JJ >= 101  THEN DO;  CALL PLIRETC(40);  GOTO Z99;  END;
      COUNTY(JJ) = CC;
      ROUTE(JJ) = RR;
      PMA(JJ) = AA;  F_A = AA;
      PMB(JJ) = BB;  F_B = BB;
      P_PMA(JJ) = 0.001 * F_A + 0.0005;
      P_PMB(JJ) = 0.001 * F_B + 0.0005;
      GOTO A01;

A06:  CLOSE FILE (DDCARDS);
      IF JJ = 0  THEN DO;  CALL PLIRETC(41);  GOTO Z99;  END;

      DO J = 1 TO JJ;
      PUT EDIT (J, COUNTY(J), ROUTE(J), PMA(J), PMB(J))
               (SKIP, F(3), X(5), A(3), X(2), F(3), X(2),
                F(7,3,-3), X(2), F(7,3,-3));
      END;
      PUT PAGE;

      J = 1;
B00:  OPEN FILE(DDIN) TITLE('DD'||C_IDENT(J));

B01:  READ FILE(DDIN) INTO(C_REC);
      IF END_DDIN = 1  THEN GOTO B03;
      CC = SUBSTR(C_REC,11,3);
      RR = SUBSTR(C_REC,14,3);
      C_PMA = SUBSTR(C_REC,28,7);
      C_PMB = SUBSTR(C_REC,37,7);
      F_A = C_PMA;
```

```
      F_B = C_PMB;
      AA = 1000.0 * F_A + 0.5;
      BB = 1000.0 * F_B + 0.5;
      IF AA > BB THEN DO;
         PUT EDIT ('PM_A > PM_B  :', C_REC)  (SKIP, A, A(62));
         CALL PLIRETC(2);
         C_SAVE = C_PMA;
         C_PMA = C_PMB;
         C_PMB = C_SAVE;
         SAVE = AA;
         AA = BB;
         BB = SAVE;
         C_SAVE = SUBSTR(C_REC,27,9);
         SUBSTR(C_REC,27,9) = SUBSTR(C_REC,36,9);
         SUBSTR(C_REC,36,9) = C_SAVE;
         END;

      DO K = 1 TO JJ;
      IF RR ¬= ROUTE(K)   THEN GOTO B02;
      IF CC ¬= COUNTY(K)  THEN GOTO B02;
      IF AA >= PMB(K)     THEN GOTO B02;
      IF BB <= PMA(K)     THEN GOTO B02;
      IF AA < PMA(K)  THEN  SUBSTR(C_REC,28,7) = P_PMA(K);
      IF BB > PMB(K)  THEN  SUBSTR(C_REC,37,7) = P_PMB(K);
      PUT   FILE(DDOUT) EDIT(C_REC) (A(300));
      SUBSTR(C_REC,28,7) = C_PMA;
      SUBSTR(C_REC,37,7) = C_PMB;
B02:  END;
      GOTO B01;

B03:  CLOSE FILE (DDIN);
      IF C_LAST_DD = 'DD'||C_IDENT(J)  THEN GOTO Z99;
      END_DDIN = 0;
      J = J + 1;
      IF J <= 26  THEN GOTO B00;

Z99:   CLOSE FILE (DDOUT);
       END MAIN;

***** END PLI SELECTION PROGRAM ***************************************
```

## APPENDIX III. SAS Edit Program

The following is the SAS program for the JCL example.

```
***** BEGIN SAS EDIT PROGRAM ************************************;

DATA MAIN;  LENGTH  COUNTY $ 3  ROUTE $ 4  CSAVE $ 9  DEFAULT=4;
     KEEP   COUNTY  ROUTE  PM_A  PM_B  RECORD01  RECORD02;

     FILE PRINT;
     INFILE DDINPUT   LENGTH=REC_LONG;
     COUNT = 0;       RLONG = 300;
     MX_COUNT = 500000;

START:  INPUT
     COUNTY      11-13
     ROUTE_N     14-16
     PM_A        28-34
     PM_B        37-43
     @ 001 RECORD01     $CHAR150.
     @ 151 RECORD02     $CHAR150.;

     IF  REC_LONG NE RLONG  THEN ABORT RETURN 15;
     ERROR = 0;
     IF COUNTY EQ ' '                          THEN ERROR = 1;
     IF ROUTE_N EQ .    OR  ROUTE_N LT 0       THEN ERROR = 1;
     IF PM_A EQ .       OR  PM_B EQ .          THEN ERROR = 1;
     IF PM_A LT 0       OR  PM_B LT 0          THEN ERROR = 1;
     IF PM_A GT 200     OR  PM_B GT 200        THEN ERROR = 1;
     IF ERROR = 1  THEN DO;
        PUT 'IDENTIFICATION ERROR  :'  RECORD01 $CHAR62.;
        GOTO START;  END;

     IF PM_A GT PM_B  THEN DO;
        PUT 'PM_A > PM_B  WARNING  :'  RECORD01 $CHAR62.;
        SAVE = PM_A;
        PM_A = PM_B;
        PM_B = SAVE;
        CSAVE = SUBSTR(RECORD01,27,9);
        SUBSTR(RECORD01,27,9) = SUBSTR(RECORD01,36,9);
        SUBSTR(RECORD01,36,9) = CSAVE;
        END;

     SUBSTR(RECORD01,11,3) = COUNTY;
     SUBSTR(RECORD01,14,3) = PUT(ROUTE_N,3.);
     SUBSTR(RECORD01,28,7) = PUT(PM_A,7.3);
     SUBSTR(RECORD01,37,7) = PUT(PM_B,7.3);

     ROUTE = SUBSTR(RECORD01,14,4);
     PM_A = INT(10000*PM_A + 0.5);
     PM_B = INT(10000*PM_B + 0.5);
     IF PM_A EQ PM_B  THEN PM_B = PM_B + 1;

     OUTPUT;
     COUNT = COUNT + RLONG;
     IF COUNT GT MX_COUNT  THEN ABORT RETURN 16;
     GOTO START;

*******************************************************************;
PROC SORT;  BY  COUNTY  ROUTE  PM_A  PM_B;

*******************************************************************;
DATA _NULL_;  LENGTH  CCC $ 3  RRR $ 4  DEFAULT=4;

     STRT_PNT = 1;
     SET MAIN POINT=STRT_PNT NOBS=TOTAL;
     FILE DDOUTPUT NOPRINT NOTITLES;

     COUNT = 0;  RLONG = 300;
```

```
    MX_COUNT = 500000;

START_C:  CCC = COUNTY;
START_R:  RRR = ROUTE;
START_A:  AAA = PM_A;
START_B:  BBB = PM_B;

    DO FNSH_PNT = STRT_PNT TO TOTAL;
    SET MAIN POINT=FNSH_PNT;
    IF CCC NE COUNTY      THEN GOTO NEXT01;
    IF RRR NE ROUTE       THEN GOTO NEXT01;
    IF AAA GE PM_B        THEN GOTO ENDA;
    IF AAA LT PM_A        THEN DO;
       IF BBB GT PM_A     THEN BBB = PM_A;  GOTO NEXT01;  END;
    IF BBB GT PM_B        THEN BBB = PM_B;
ENDA:  END;
    FNSH_PNT = TOTAL + 1;

NEXT01:
    FNSH_PNT = FNSH_PNT - 1;
    DO NEW_PNT = STRT_PNT TO FNSH_PNT;
    SET MAIN POINT=NEW_PNT;
    IF AAA GE PM_B  THEN GOTO ENDB;
    PMA = 0.0001*AAA;
    PMB = 0.0001*BBB;
    SUBSTR(RECORD01,28,7) = PUT(PMA,7.3);
    SUBSTR(RECORD01,37,7) = PUT(PMB,7.3);
    PUT @ 001 RECORD01 $CHAR150.
        @ 151 RECORD02 $CHAR150.;
    COUNT = COUNT + RLONG;
    IF  COUNT GT MX_COUNT  THEN ABORT RETURN 16;
ENDB:   END;

*   RESET STARTING VARIABLES    ******************;
    FRST_PNT = STRT_PNT;
    DO STRT_PNT = FRST_PNT TO TOTAL;
    SET MAIN POINT=STRT_PNT;
    IF CCC NE COUNTY    THEN GOTO START_C;
    IF RRR NE ROUTE     THEN GOTO START_R;
    IF BBB LT PM_A      THEN GOTO START_A;
    IF BBB LT PM_B      THEN DO;  AAA = BBB;  GOTO START_B;  END;
    END;
    STOP;

***** END SAS EDIT PROGRAM ***************************************;
```